Citation:

Libuda L, Alexy U, Sichert-Hellert W, Stehle P, Karaolis-Danckert N, Buyken AE, Kersting M. Pattern of beverage consumption and long-term association with body-weight status in German adolescents-results from the DONALD study. *Br J Nutr*. 2008 Jun; 99 (6): 1,370-1,379.

PubMed ID: 18034911

Study Design:

Prospective Cohort Study

Class:

B - Click here for explanation of classification scheme.

Research Design and Implementation Rating:

NEUTRAL: See Research Design and Implementation Criteria Checklist below.

Research Purpose:

- To examine the five-year consumption patterns of soft drinks and fruit juices and changes in consumption during the observation period in a group of German adolescents
- To determine whether an association exists between beverage consumption and body-weight status.

Inclusion Criteria:

- Data from when subjects were ages nine to 18 years with at least four out of six possible dietary records
- Subject inclusion criteria for the Dortmund Nutritional and Anthropometric Longitudinally Designed (DONALD) study are reported elsewhere.

Exclusion Criteria:

- Under-reporters. Under-reporting was defined as having a ratio of reported total energy intake and predicted individual basal metabolic rate (BMR) below the age- and sex-specific cut-off values of:
  - 1.04 for boys and 1.01 for girls (six to 13 years old)
  - 1.07 for boys and 0.97 for girls (14 to 18 years old)
- Subject exclusion criteria for the Dortmund Nutritional and Anthropometric Longitudinally Designed (DONALD) study are reported elsewhere.

Description of Study Protocol:

Recruitment

- Subjects in this study were part of the larger Dortmund Nutritional and Anthropometric

Longitudinally Designed (DONALD) study
- Recruitment information for the DONALD study are reported elsewhere.

Design

- The DONALD study is an observational, non-invasive longitudinal study that collects information on the nutrition, development, metabolism and health status of subjects between infancy and early adulthood. For this study, data from subjects aged nine to 18 years was analyzed to determine whether five-year consumption patterns of beverage intake were related to weight status. The age range of 14-18 years was chosen based on a previous analysis of DONALD data that suggested the highest average soft drink consumption was in subjects over age nine years
- For analysis, beverage intake was group as follows:
    - Regular soft drinks: Carbonated and non-carbonated sugar-sweetened beverages
    - Diet soft drinks
    - Fruit juices (100% fruit juice)
    - Energetic beverages: A combined variable made up of both regular soft drinks and fruit juice
- Diet soft drinks were excluded from the analyses of beverage consumption and weight status due to the small number of subjects who consumed this type of beverage.

Dietary Intake/Dietary Assessment Methodology

- Dietary intake data was collected using three-day weighed food records, in which subjects and their caretakers were asked to weigh all foods and beverages before and after consumption on three consecutive days. About 75% of dietary data was from weekdays and 25% was from weekend days. Semi-quantitative reporting (e.g., numbers of glasses, cups) was allowed if weighing was not possible
- Energy and nutrient intakes were calculated using LEFTAB, an in-house nutrient database which contains detailed data on the energy and nutrient content of all recorded food items and is continuously updated. The nutrient content of basic food items was taken from standard nutrient tables, and the content of commercial food items was derived either from the product labels or from simulating recipes from the ingredients listed on the labels.

Blinding Used

Not applicable.

Intervention

Not applicable.

Statistical Analysis

- Intakes of energy and beverage groups were calculated as individual means of the three-day weighed food records
- Wilcoxon rank sum test was used for testing the differences between sexes in beverage consumption
- Differences in frequencies of overweight and obesity were analyzed using the Fisher's exact test
- Differences between baseline (first individual assessment) and last individual assessment values were tested by the Wilcoxon signed-rank test
- For analyzing the association between beverage consumption and body-weight status the

energy derived from a particular beverage group (mJ) was chosen as an indicator of beverage consumption
- A repeated-measures regression model (PROC MIXED) was used for testing the association between baseline beverage consumption (mJ) and baseline values of body-weight status, baseline beverage consumption and change in body-weight status over a five-year period, and change in beverage consumption and concurrent changed in body-weight status.
    - In the repeated-measures regression models regular soft drinks and juices were included at the same time as independent variables to consider possible mutual confounding
    - Separate analyses included either BMI-SDS or percentage body fat (BF) as the dependent variables
    - There was a significant interaction of sex, so data from boys and girls was analyzed separately
    - All basic models were controlled for various confounders, including: Time in years after maximal growth velocity (equals years of adolescence) as an indicator of pubertal status, weight at birth, year of birth, maternal BMI and maternal education level. Data were not controlled forphysical activity, as sufficient information regarding physical activity was not available for most of the study sample
- To test for subjects' compensation for energy consumed in liquid form, cross-sectional correlation between the energy consumed from energetic beverages and the residual energy intake at each time point was calculated. If there was any compensation for the beverages, the correlation coefficient would be negative
- For all statistical tests, a P-value of $P<0.05$ was considered to be significant.

Data Collection Summary:

Timing of Measurements

- All measurements were collected on an annual basis
- Dietary intake data and weight status data were collected at the same time for each time-point.

Dependent Variables

- Body weight status: Body weight and height were measured by study coordinators and BMI was calculated as body weight (kg) divided by height (m) squared. Sex- and age-independent BMI standard deviation scores (BMI-SDS) were calculated using the German national reference data. Overweight was defined as BMI values between the 90th and the 97th percentiles, and obesity was defined as BMI values above the 97th percentile of German national reference data
- Body Fat Percentage (Percentage BF): Triceps and subscapular skinfolds were measures on the right side of the body using a skinfold caliper. The sum of both skinfolds was used for the estimation of body fat percentage (Percentage BF) according to the equations of Slaughter et al, 1988.

Independent Variables

- Beverage consumption (grams per day) and energy intake was calculated using three-day weighed food records
- Energy and nutrient intakes were calculated using the nutrient database LEFTAB.

Control Variables

- Weight at birth was abstracted from the "Mutterpass," a standardized document given to all pregnant women in German where anthropometric data at birth are obligatorily recorded
- Parents were weighed and measured by the study nurses at the time of their child's admission to the DONALD study, and this information was used to calculate maternal BMI.

Description of Actual Data Sample:

- *Initial N:* At the time of the study, 1,170 subjects had been enrolled in the DONALD study
- *Attrition (final N):*
  - Data from 244 subjects (125 boys and 119 girls) were included in the final analysis
  - 1,316 dietary records were included from these 244 subjects
- *Age:*
  - Boys:
    - Baseline: 11.9±1.6 years
    - Last assessment: 16.8±1.5 years
  - Girls:
    - Baseline: 11.8±1.5 years
    - Last assessment: 16.8±1.5 years
- *Ethnicity:* Not reported
- *Other Relevant Demographics:* None reported
- *Anthropometrics:* None
- Boys (baseline/last assessment)
  - Height: 154.9±12.4cm / 179.5±1.5cm
  - Weight: 44.3±11.0kg / 69.1±11.7kg
  - BMI: 18.15±2.3kg/m^2 / 21.33±2.73kg/m^2
  - BMI-SDS: -0.05±0.846 / 0.033±0.943
  - Percentage overweight: 4% / 6.4%
  - Percentage obese: 0% / 0.8%
  - Body fat percentage: 17.8±6.2% / 16.4±7.8%
- Girls (baseline/last assessment)
  - Height: 154.7±11.7cm / 169.0±6.2cm
  - Weight: 44.8±11.4kg / 61.8±10.7kg
  - BMI: 18.43±2.8kg/m^2 / 21.58±3.13kg/m^2
  - BMI-SDS: -0.048±0.993 / 0.117±1.057
  - Percentage overweight: 8.4% / 5.0%
  - Percentage obese: 1.7% / 5.9%
  - Body fat percentage: 20.6±7.1% / 26.3±7.3%
- *Location:* Dortmund, Germany.

Summary of Results:

Anthropometric Measurements

- Both boys and girls showed a significant increase in BMI from baseline to the last assessment ($P<0.05$)
- BMI-SDS increase significantly only in girls ($P<0.05$), implying that girls in this sample were increasing BMI at a rate slightly higher than the German national standard.

Beverage Consumption

- In five-year averages, represented 23.8% of total beverage consumption for boys and 20.6% of total beverage consumption for girls
- Fruit juice accounted for 14.9% of total beverage consumption for boys and 16.4% of total beverage consumption for girls
- At baseline, beverage consumption patterns did not differ significantly between boys and girls. However, at the last assessment, consumption of regular soft drinks and all energetic beverages was higher in boys ($P<0.001$).
- From baseline to the last assessment, boys significantly increased their consumption of all beverage types ($P<0.05$), but girls only significantly increased their fruit juice consumption ($P<0.05$).

Beverage Consumption and Weight Status

- Boys
  - There were no associations between baseline all energetic beverage consumption and BMI-SDS or percentage of body fat, nor were there any for change in all energetic beverage consumption and change in BMI-SDS or change in percentage body fat
  - A higher baseline consumption of fruit juice was associated with a higher baseline BMI-SDS ($P<0.05$), but change in fruit juice consumption did not predict changes in BMI-SDS or percentage body fat.
- Girls
  - There were no associations between baseline all energetic beverage consumption and BMI-SDS or percentage body fat
  - Change in energetic beverage intake significantly predicted change in BMI-SDS; for each additional mJ of energetic beverage consumed, BMI-SDS of girls increased by 0.07 units ($P=0.010$). Change in energetic beverage consumption was not associated with change in percentage body fat
  - Change in fruit juice consumption was associated with a change in BMI-SDS (+0.096 SDS/MJ; $P=0.01$)
  - Baseline consumption of regular soft drinks was significantly negatively correlated with baseline percentage body fat ($P=0.05$).

Beverage Compensation

For both boys and girls, there was NS correlation between consumption of energetic beverages and residual energy intake, showing the consumption of energetic beverages was not adequately compensated for by restriction of other energetic foods.

Author Conclusion:

- For girls, change in energetic beverage consumption (regular soft drinks and fruit juice combined) over a five-year period was positively associated with change in BMI-SDS, which was primarily the result of fruit juice consumption. Therefore, consumption of energetic beverages may be related to increased risk of becoming overweight over time in adolescent girls
  - An increase of 0.07 units in BMI-SDS was seen for every additional unit in energetic beverage consumption over the five-year study period
- In boys, there was only a positive cross-sectional association between fruit juice consumption at baseline and baseline BMI-SDS

- There was no association between energetic beverage consumption and percentage of body fat in boys and girls
- There was no correlation between consumption of energetic beverages and residual energy intake, suggesting that energy consumed as beverages is not fully compensated for by lower consumption of other energy-containing foods.

Reviewer Comments:

- *The study population had very small numbers of overweight and obese subjects at both baseline and at the last assessment. Therefore, it is possible that the study did not have enough statistical power to see differences in body weight status by beverage consumption*
- *Subjects in the DONALD study have been continuously enrolling since 1985. Therefore, because all DONALD subjects with four full sets of data from between ages nine and 18 years were included in this study, it is likely that the data analyzed is from a range of years between 1985 and 2008. It is unclear how changes in beverage consumption patterns over that large time period may have influenced study findings.*

Research Design and Implementation Criteria Checklist: Primary Research

Relevance Questions

1.	Would implementing the studied intervention or procedure (if found successful) result in improved outcomes for the patients/clients/population group? (Not Applicable for some epidemiological studies)	N/A
2.	Did the authors study an outcome (dependent variable) or topic that the patients/clients/population group would care about?	Yes
3.	Is the focus of the intervention or procedure (independent variable) or topic of study a common issue of concern to nutrition or dietetics practice?	Yes
4.	Is the intervention or procedure feasible? (NA for some epidemiological studies)	N/A

Validity Questions

1.	**Was the research question clearly stated?**	Yes
1.1.	Was (were) the specific intervention(s) or procedure(s) [independent variable(s)] identified?	Yes
1.2.	Was (were) the outcome(s) [dependent variable(s)] clearly indicated?	Yes
1.3.	Were the target population and setting specified?	Yes
2.	**Was the selection of study subjects/patients free from bias?**	Yes

2.1.	Were inclusion/exclusion criteria specified (e.g., risk, point in disease progression, diagnostic or prognosis criteria), and with sufficient detail and without omitting criteria critical to the study?	Yes
2.2.	Were criteria applied equally to all study groups?	Yes
2.3.	Were health, demographics, and other characteristics of subjects described?	Yes
2.4.	Were the subjects/patients a representative sample of the relevant population?	No
3.	**Were study groups comparable?**	No
3.1.	Was the method of assigning subjects/patients to groups described and unbiased? (Method of randomization identified if RCT)	N/A
3.2.	Were distribution of disease status, prognostic factors, and other factors (e.g., demographics) similar across study groups at baseline?	No
3.3.	Were concurrent controls used? (Concurrent preferred over historical controls.)	No
3.4.	If cohort study or cross-sectional study, were groups comparable on important confounding factors and/or were preexisting differences accounted for by using appropriate adjustments in statistical analysis?	No
3.5.	If case control or cross-sectional study, were potential confounding factors comparable for cases and controls? (If case series or trial with subjects serving as own control, this criterion is not applicable. Criterion may not be applicable in some cross-sectional studies.)	Yes
3.6.	If diagnostic test, was there an independent blind comparison with an appropriate reference standard (e.g., "gold standard")?	N/A
4.	**Was method of handling withdrawals described?**	Yes
4.1.	Were follow-up methods described and the same for all groups?	N/A
4.2.	Was the number, characteristics of withdrawals (i.e., dropouts, lost to follow up, attrition rate) and/or response rate (cross-sectional studies) described for each group? (Follow up goal for a strong study is 80%.)	Yes
4.3.	Were all enrolled subjects/patients (in the original sample) accounted for?	Yes
4.4.	Were reasons for withdrawals similar across groups?	???
4.5.	If diagnostic test, was decision to perform reference test not dependent on results of test under study?	N/A
5.	**Was blinding used to prevent introduction of bias?**	Yes

5.1.	In intervention study, were subjects, clinicians/practitioners, and investigators blinded to treatment group, as appropriate?	N/A
5.2.	Were data collectors blinded for outcomes assessment? (If outcome is measured using an objective test, such as a lab value, this criterion is assumed to be met.)	Yes
5.3.	In cohort study or cross-sectional study, were measurements of outcomes and risk factors blinded?	Yes
5.4.	In case control study, was case definition explicit and case ascertainment not influenced by exposure status?	N/A
5.5.	In diagnostic study, were test results blinded to patient history and other test results?	N/A
6.	**Were intervention/therapeutic regimens/exposure factor or procedure and any comparison(s) described in detail? Were interveningfactors described?**	Yes
6.1.	In RCT or other intervention trial, were protocols described for all regimens studied?	N/A
6.2.	In observational study, were interventions, study settings, and clinicians/provider described?	Yes
6.3.	Was the intensity and duration of the intervention or exposure factor sufficient to produce a meaningful effect?	Yes
6.4.	Was the amount of exposure and, if relevant, subject/patient compliance measured?	Yes
6.5.	Were co-interventions (e.g., ancillary treatments, other therapies) described?	N/A
6.6.	Were extra or unplanned treatments described?	N/A
6.7.	Was the information for 6.4, 6.5, and 6.6 assessed the same way for all groups?	Yes
6.8.	In diagnostic study, were details of test administration and replication sufficient?	N/A
7.	**Were outcomes clearly defined and the measurements valid and reliable?**	Yes
7.1.	Were primary and secondary endpoints described and relevant to the question?	Yes
7.2.	Were nutrition measures appropriate to question and outcomes of concern?	Yes
7.3.	Was the period of follow-up long enough for important outcome(s) to occur?	Yes
7.4.	Were the observations and measurements based on standard, valid, and reliable data collection instruments/tests/procedures?	Yes
7.5.	Was the measurement of effect at an appropriate level of precision?	???
7.6.	Were other factors accounted for (measured) that could affect outcomes?	Yes

7.7.	Were the measurements conducted consistently across groups?	Yes
8.	**Was the statistical analysis appropriate for the study design and type of outcome indicators?**	Yes
8.1.	Were statistical analyses adequately described and the results reported appropriately?	Yes
8.2.	Were correct statistical tests used and assumptions of test not violated?	Yes
8.3.	Were statistics reported with levels of significance and/or confidence intervals?	Yes
8.4.	Was "intent to treat" analysis of outcomes done (and as appropriate, was there an analysis of outcomes for those maximally exposed or a dose-response analysis)?	Yes
8.5.	Were adequate adjustments made for effects of confounding factors that might have affected the outcomes (e.g., multivariate analyses)?	Yes
8.6.	Was clinical significance as well as statistical significance reported?	Yes
8.7.	If negative findings, was a power calculation reported to address type 2 error?	No
9.	**Are conclusions supported by results with biases and limitations taken into consideration?**	Yes
9.1.	Is there a discussion of findings?	Yes
9.2.	Are biases and study limitations identified and discussed?	Yes
10.	**Is bias due to study's funding or sponsorship unlikely?**	Yes
10.1.	Were sources of funding and investigators' affiliations described?	Yes
10.2.	Was the study free from apparent conflict of interest?	Yes